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Relationship between rainfall, runoff, soil loss and productivity in north eastern ghat zone of odisha

Abstract

A trial was conducted at All India Coordinated Research Project ,OUAT, Phulbani during the year 2007-09 with the objectives to quantify the runoff and soil loss under different cropping systems and develop relationship among them. The treatments tried were T_1-Sole crop of rice, T_2- Sole crop of pigeon pea. T_3-Sole crop of groundnut,T_4-Pigeonpea and rice in alternate strips, T_5- Pigeon pea and groundnut in alternate strips, T_6-Intercrop of rice and pigeon pea (5:2), T_7- Intercrop of groundnut and pigeon pea (4:2),T_8-Uncultivated fallow,T_9-Cultivated fallow, All crops were planted across the contour. Intercrop of groundnut and pigeon pea (4:2) gave significantly higher rice equivalent yield compared to other sole crops. Mean rice equivalent yield was 38.62q/ha. Groundnut + pigeon pea (4:2) introduction increased the yield by 158% as 97% and 21% when compared with sole crop of rice, pigeon pea and groundnut respectively. Groundnut + pigeon pea (4:2) gave the lowest runoff of 309mm which is 23% less than the cultivated fallow (401mm).Groundnut + pigeon pea (4:2) gave the lowest soil loss (8.03t/ha) which is 47% lower than the cultivated fallow (with highest soil loss 15.19 t/ha).The Groundnut + pigeon pea (4:2) gave the lowest (24.2%) mean runoff of the rainfall compared to other treatments. The relationship among rainfall, runoff and soil loss was found out which can be used to predict the runoff and soil loss from rainfall for same type of soil condition and slope. The Thus it can be concluded that intercropping of groundnut with pigeon pea planted along contour may be practiced to increase crop yield and lowering the soil loss and runoff in the hilly tribal areas of Kandhamal district of Odisha.

Keywords: relationship, rainfall, runoff, soil loss, productivity

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Introduction

Strip and intercropping of cereal crops with pulses/oilseeds are approved practices of breaking long slopes, which prevent soil loss, reduce runoff and enhance productivity. Therefore, this experiment has been designed to know the effect of strip as well as intercrop of pigeonpea, rice and groundnut on runoff, soil loss and productivity on sloppy agricultural land. These intangible benefits have not been assessed properly. Hence the present experiment has been designed. Samra JS[1] reported that renovation of terrace and plantation of fruit plants, timber plants improved biomass production, net returns, growth of crop, productivity, reduction of runoff in the range of 1.5-10.8 times, peak flow rate by 20 times& soil loss in the range of 1.2 to 5.2 times ,as well as water table rise. Subudhi et al.,[2] have reported that effect of vegetative barrier like Vetiver has increased the rice yield, decrease the soil loss and decrease the runoff compared to farmers practice. Arora et al.,[3] reported that there is a growing need for rain water management since 96 m ha out of 142 m ha of net cultivated land of the country is rainfed. Scientific use of these resources will definitely increase the productivity &conservation of resources like soil & water. Kumar[4] reported that impact of different soil& water conservation techniques viz. contour bunding, terracing, land leveling, smoothening& gully plugging, sowing across the slope, vegetative barrier, increase the Kharif crops by 25-30 percent. Establishment of vegetative barrier with mechanical measures were more effective in controlling soil erosion(3.8 t ha^{-1}) over conventional method(9.64 t ha^{-1})and runoff thereby making more moisture available for crop growth. Anonymous[5-7] reported that intercropping of groundnut with pigeonpea planted along contour gave the highest rice equivalent yield, lowest soil loss and runoff.

Objectives

To quantify the runoff and soil loss under different cropping systems and develop relationship among them.

Materials and methods

A trial was conducted at All India Coordinated Research Project, OUAT, Phulbani during the year 2007-09. The experiment was laid out on 2% land slope. Multi slot division box and drums were put to measure the runoff and soil loss daily after each rainfall. The treatments tried were T_1-Sole crop of rice, T_2- Sole crop of pigeon pea. T_3-Sole crop of groundnut, T_4-Pigeonpea and rice in alternate strips, T_5- Pigeon pea and groundnut in alternate strips, T_6-Intercrop of rice and pigeon pea (5:2), T_7- Intercrop of groundnut and pigeon pea (4:2), T_8-Uncultivated fallow, T_9-Cultivated fallow, All crops were planted across the contour. Different crops and their varieties are, Rice- ZHU-11-26; Pigeon pea - UPAS-120; Groundnut- Smruti (OG-52-1). The experiment design was Randomized Block Design and numbers of replications were three. Plot size was 25mX2m. Seed rate were, Rice-75kg/ha; Pigeon pea-25kg/ha; Groundnut-150kg/ha (pod). Fertilizer applied was;

Basal: Rice-30:30:30kg N-P_2O_5-K_2O/ha; Pigeon pea-20:40:20kg N-P_2O_5-K_2O/haGroundnut-20: 40:40 kg N-P_2O_5-K_2O/ha.

Top dressing: Rice- 30kg N in two splits.

The runoff collected daily at 8 AM was measured from the drum and 1 lit of runoff from each drum were collected for silt analysis, so soil loss can be measured from the silt sample collected after evaporating the sample in the heater. The rainfall was also measured. Thus the relation between rainfall (mm)-runoff (mm), rainfall (mm)-

soil loss (t/ha) and runoff (mm)-soil loss (t/ha) were calculated and coefficient of determination was also calculated.

Result and discussion

Rainfall, runoff and soil loss: During 2009 Pigeon pea received the highest amount of rainfall (1544.8mm) this cropping treatment received the highest amount of runoff (516mm) In addition, Groundnut + pigeon pea (4:2) gave the lowest runoff of 309mm which is 23 % less than the cultivated fallow (401mm).Groundnut + pigeon pea (4:2) gave the lowest soil loss (8.03t/ha) (Table 1) which is 47 % lower than the cultivated fallow (with highest soil loss 15.19 t/ha). The Groundnut + pigeon pea (4:2) gave the lowest (24.2 %) mean runoff of the rainfall compared to other treatments. The poor and marginal farmers having lands in upland ecosystem may go for this technology Figures 1-6.

Table 1 Runoff and soil loss under different cropping systems during 2007 to 2009 (3 years)

Treatments	Run off (mm)				Soil loss(t/ha)				Run off (% of rainfall)			
	2007	8	9	Mean	2007	8	9	Mean	2007	2008	2009	Mean
T1 – Rc Sole	221.268	295.34	514	344	6.72	10.01	12.6	9.78	21.7	25.3	33.3	26.8
T2- Pp Sole	226.92	296.43	516	347	7.116	10.06	12.65	9.94	22.26	25.4	33.4	27
T3-Gn Sole	221.943	284.03	508	338	6.49	9.35	12.43	9.42	21.77	24.3	32.9	26.3
T4-Pp & Rc strip cropping	221.1	279.48	487	329	6.47	9.59	11.84	9.3	21.68	23.9	31.5	25.7
T5- Pp & Gn strip cropping	220.003	275.85	482	326	6.708	9.47	11.75	9.31	21.58	23.6	31.2	25.5
T6-Rc + Pp (5:2) intercropping	217.725	270.03	471	320	6.358	9.32	9.81	8.5	21.35	23.1	30.5	25
T7-Gn+ Pp (4:2) intercropping	213.376	258.39	456	309	6.231	8.61	9.25	8.03	20.96	22.1	29.5	24.2
T8- Uncultivated fallow	234.175	347.72	555	379	7.395	11.92	17.84	12.39	22.97	29.8	35.9	29.6
T9- Cultivated fallow	250.119	364.68	588	401	9.772	15.99	19.82	15.19	24.53	31.2	38.1	31.3
Mean	225.214	296.88	509	344	7.029	10.48	13.11	10.21	22.09	25.4	32.9	26.8

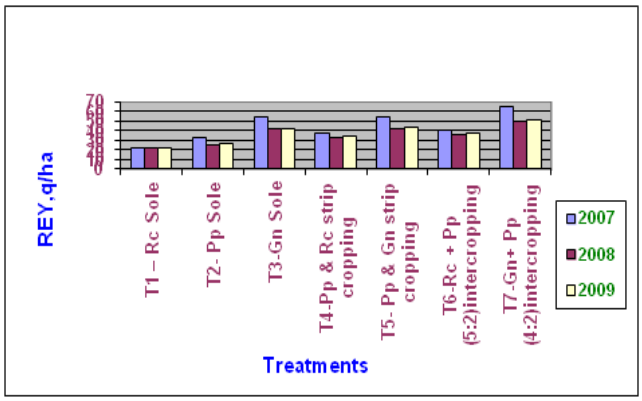

Figure 1 Rice equivalent yield in different years.

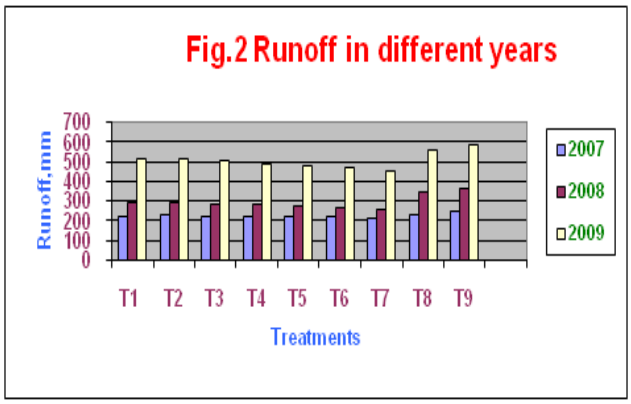

Figure 2 Runoff in different year.

Citation: Subudhi CR, Senapati SC. Relationship between rainfall, runoff, soil loss and productivity in north eastern ghat zone of odisha. *Biom Biostat Int J.* 2016;4(2):84–89. DOI: 10.15406/bbij.2016.04.00093

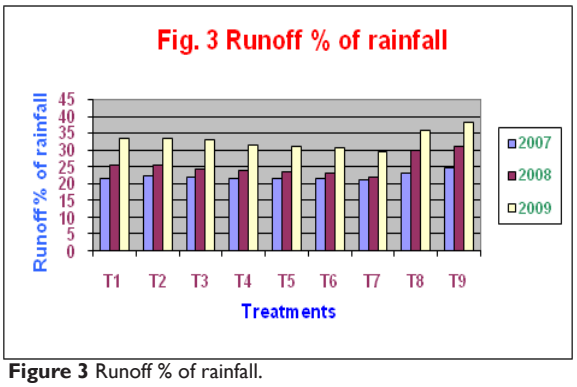

Figure 3 Runoff % of rainfall.

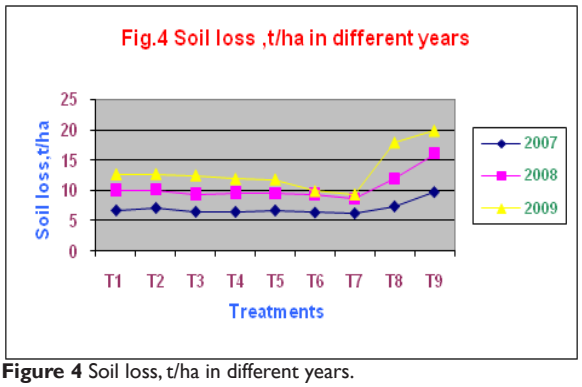

Figure 4 Soil loss, t/ha in different years.

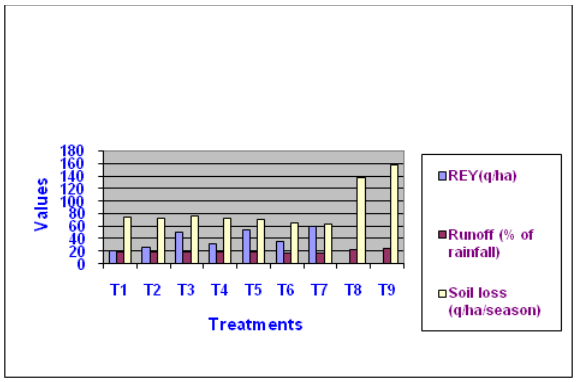

Figure 5 Rice Equivalent Yield (REY), Runoff and soil loss in different treatments.

Figure 6 Multi slot division box with runoff collection tank.

Moisture content: From Table 2 it is observed that the Gn+Pp (4:2) intercropping gave highest moisture content, plant height and other yield attributing characters compared to other treatments so moisture content might be the reason to increase the yield.

Table 2 Mean moisture content and yield attributing characteristics during 2007-09

Treatments	Mean Moisture Content
T1 – Rc Sole	15.5
T2- Pp Sole	16.1
T3-Gn Sole	16
T4-Pp & Rc strip cropping	16.2
T5- Pp & Gn strip cropping	17.6
T6-Rc + Pp (5:2)intercropping	17.1
T7-Gn+ Pp (4:2)intercropping	17.8
T8- Uncultivated fallow	15.6
T9- Cultivated fallow	15.2
SE (m)+	0.251
CD(0.05)	0.903
Mean	16.3

Nutrient loss: Nutrient loss in different treatments were shown in Table 3, it is observed that total nutrient loss was highest in treatment 9 i.e. Cultivated fallow may be due to the reason that soil surface was exposed without any crop and cultivated and also soil loss was more in this treatment compared to other treatments. Lowest nutrient loss was in T_7 (42.21kg/ha) i.e. -Gn+ Pp (4:2) intercropping.

Table 3 Nutrient lost from soil sample collected from runoff from different treatments

Treatments	Nutrient loss from different treatments, Kg/ha			Total nutrient loss, kg/ha
	N	P_2O5	K_2O	
T1 – Rc Sole	11.5	10.14	29.7	51.34
T2- Pp Sole	11.5	13.24	35.62	60.36
T3-Gn Sole	13.13	12	28.76	53.89
T4-Pp & Rc strip cropping	11.13	9.69	23.52	44.34
T5- Pp & Gn strip cropping	11.5	7.16	27.42	46.08
T6-Rc + Pp (5:2) intercropping	10.38	6.14	25.94	42.46
T7-Gn+ Pp (4:2) intercropping	12.25	4.62	25.34	42.21
T8- Uncultivated fallow	11.5	4.17	36.02	51.69
T9- Cultivated fallow	16.25	2.82	45.43	64.5

Citation: Subudhi CR, Senapati SC. Relationship between rainfall, runoff, soil loss and productivity in north eastern ghat zone of odisha. *Biom Biostat Int J.* 2016;4(2):84–89. DOI: 10.15406/bbij.2016.04.00093

Yield attributing characteristics: The biometric characteristics of different crops under different treatments is given in Table 4 it is observed that the Gn+Pp (4:2) intercropping gave highest plant height and other yield attributing characters compared to other treatments.

Table 4 Mean yield attributing characteristics during 2007-09

Treatments	Rice			Pigeonpea			Groundnut		
	Plant height, cm	Penicle length, cm	No of tillers /m run	Plant height, cm	Spread, cm	No of branches	Plant height, cm	No of branches	No of pods per plant
T1 – Rc Sole	71.4	17	51.5						
T2- Pp Sole				186.6	93.2	22.1			
T3-Gn Sole							65.4	8	35.2
T4-Pp & Rc strip cropping	74.6	17.4	53.8	191.6	99.4	22.2			
T5- Pp & Gn strip cropping				198	106	23.1	74.5	8.6	37.9
T6-Rc + Pp (5:2) inter cropping	78.1	18.2	61.2	201.7	97.9	21.9			
T7-Gn+ Pp (4:2) inter cropping				209.6	106.8	23.1	76	9	42.1
Mean	74.7	17.5	55.5	197.5	100.7	22.5	72	8.5	38.4

Yield: Intercrop of groundnut and pigeonpea (4:2) gave significantly higher rice equivalent yield compared to other sole crops. Mean rice equivalent yield was 38.62 q/ha. Groundnut + pigeonpea (4:2) introduction increased the yield by 158 % as 97% and 21% when compared with sole crop of rice, pigeonpea and groundnut respectively (Table 5).

Table 5 Rice equivalent yield, under different cropping systems during 2007 to 2009 (3 years)

Treatments	REY(q/ha)			
	2007	8	9	Mean
T1 – Rc Sole	21.047	21.17	22.38	21.53
T2- Pp Sole	33.393	25.436	25.85	28.23
T3-Gn Sole	54.179	41.307	41.87	45.79
T4-Pp & Rc strip cropping	37.528	32.584	33.7	34.6
T5- Pp & Gn strip cropping	53.784	42.448	44.25	46.83
T6-Rc + Pp (5:2) intercropping	40.429	35.843	37.08	37.78
T7-Gn+ Pp (4:2) intercropping	65.996	49.043	51.68	55.57
T8- Uncultivated fallow				
T9- Cultivated fallow				
SE (m)+	0.961	0.612	0.601	0.586
CD(0.05)	2.914	1.885	1.823	1.778
Mean	43.78	35.404	36.69	38.62

Economics: From Table 6 it is observed that the Gn+Pp (4:2) intercropping gave highest mean B:C ratio i.e. 2.06 compared to all other treatments among all the cropping system treatments.

Table 6 Economics and Rain water use efficiency during 2007-09 as affected by different in-situ conservation practices

Treatments	Cost of Cultivation (Rs/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C Ratio	Rain Water Use Efficiency (Kg/ha/mm)
T1 – Rc Sole	14,000	17,933	3,933	1.28	1.62
T2- Pp Sole	14,200	23,391	9,191	1.65	1.67
T3-Gn Sole	21,721	39,582	17,861	1.82	2.91
T4-Pp & Rc strip cropping	17,861	28,866	11,005	1.62	2.18
T5- Pp & Gn strip cropping	19,294	38,839	19,545	2.01	2.86
T6-Rc + Pp (5:2) intercropping	19,166	32,222	13,056	1.68	2.4
T7-Gn+ Pp (4:2) intercropping	22,577	46,411	23,834	2.06	3.35

Citation: Subudhi CR, Senapati SC. Relationship between rainfall, runoff, soil loss and productivity in north eastern ghat zone of odisha. *Biom Biostat Int J.* 2016;4(2):84–89. DOI: 10.15406/bbij.2016.04.00093

The relationship between rainfall (mm), runoff (mm) and soil loss t/ha was presented in Table 7-9. The correlation coefficient was also found out. The relationship among rainfall, runoff and soil loss was found out which can be used to predict the runoff and soil loss from rainfall for same type of soil condition and slope.

Table 7 Relation between Rainfall (X)mm, Runoff(Y)mm and Soil loss (Z) t/ha in different treatments along with co-efficient of determination (2007-08)

Treatments	Relations		
	Rainfall(X) mm & runoff(Y)mm (Co.det.)	**Rainfall(X)mm & soil loss(Z) t/ha (Co.det)**	**Runoff(Y)mm & soil loss(Z)t/ha (Co.det)**
T1 – Rc Sole	Y=0.36-0.011X+0.004X2 (0.969)	Z= 0.03-0.006X+0.0002X2 (0.96)	Z= -0.101+0.043Y(0.976)
T2- Pp Sole	Y=0.49-0.015X+0.004X2 (0.966)	Z=0.033-0.007X+0.0002X2 (0.957)	Z= -0.102+0.044Y(0.983)
T3-Gn Sole	Y=0.426-0.004X+0.004X2 (0.968)	Z=0.023-0.004X+0.0002X2 (0.965)	Z= -0.079+0.039Y(0.988)
T4-Pp & Rc strip cropping	Y= 0.427-0.005X+0.004X2 (0.968)	Z= 0.023-0.004X+0.0002X2 (0.965)	Z= -0.079+0.039Y(0.988)
T5- Pp & Gn strip cropping	Y= 0.401-0.0003X+0.004X2 (0.969)	Z= 0.032-0.006X+0.0002X2 (0.958)	Z= -0.1+0.043Y(0.976)
T6-Rc+Pp (5:2) intercropping	Y= 0.383-0.002X+0.004X2 (0.969)	Z= 0.021-0.004X+0.0002X2 (0.967)	Z= -0.078+0.039Y(0.988)
T7-Gn+Pp (4:2) intercropping	Y= 0.346-0.008X+0.004X2 (0.970)	Z= 0.02-0.004X+0.0002X2 (0.969)	Z= -0.076+0.039Y(0.987)
T8-Uncultivated fallow	Y= 0.65-0.045X+0.005X2 (0.963)	Z=0.04-0.008X+0.0003X2 (0.952)	Z= -0.104+0.044Y(0.984)
T9-Cultivated fallow	Y= 0.97-0.104X+0.006X2 (0.955)	Z=0.052 –0.01X+0.0003X2 (0.951)	Z= -0.098+0.05Y(0.996)

Table 8 Relation between Rainfall (X)mm, Runoff(Y)mm and Soil loss (Z) t/ha in different treatments along with co-efficient of determination (2008-09).

Treatments	Relations		
	Rainfall(X) mm & runoff(Y)mm (Co.det.)	**Rainfall(X)mm & soil loss(Z) t/ha (Co.det)**	**Runoff(Y)mm & soil loss(Z)t/ha (Co.det)**
T1 – Rc Sole	Y=-0.5+0.156X+0.002X2 (0.975)	Z= -0.019+0.003X+0.0001X2 (0.973)	Z= -0.075+0.041Y(0.993)
T2- Pp Sole	Y=-0.432+0.152X+0.002X2 (0.975)	Z= -0.019+0.003X+0.0001X2 (0.974)	Z= -0.077+0.042Y(0.994)
T3-Gn Sole	Y=-0.414+0.14X+0.002X2 (0.975)	Z= -0.017+0.003X+0.0001X2 (0.967)	Z= -0.078+0.041Y(0.991)
T4-Pp & Rc strip cropping	Y= -0.532+0.15X+0.002X2 (0.977)	Z= -0.01+0.002X+0.0001X2 (0.976)	Z= -0.075+0.042Y(0.993)
T5- Pp & Gn strip cropping	Y= -0.531+0.15X+0.002X2 (0.977)	Z= -0.018+0.003X+0.0001X2 (0.976)	Z= -0.075+0.042Y(0.993)
T6-Rc+Pp (5:2) intercropping	Y= -0.571+0.15X+0.002X2 (0.974)	Z= -0.018+0.003X+0.0001X2 (0.973)	Z= -0.074+0.042Y(0.993)
T7-Gn+Pp (4:2) intercropping	Y= -0.513+0.136X+0.002X2 (0.972)	Z= -0.018+0.003X+0.0001X2 (0.961)	Z= -0.081+0.041Y(0.99)
T8-Uncultivated fallow	Y= -0.1+0.14X+0.004X2 (0.976)	Z= -0.018+0.003X+0.0001X2 (0.974)	Z= -0.083+0.042Y(0.996)
T9-Cultivated fallow	Y= -0.2+0.14X+0.003X2 (0.967)	Z= -0.018+0.003X+0.0001X2 (0.693)	Z= -0.097+0.052Y(0.997)

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Table 9 Relation between Rainfall (X)mm, Runoff(Y)mm and Soil loss (Z) t/ha in different treatments along with co-efficient of determination (2009-10)

Treatments	Relations		
	Rainfall(X) mm & runoff(Y)mm (Co.det.)	**Rainfall(X)mm & soil loss(Z) t/ha (Co.det)**	**Runoff(Y)mm & soil loss(Z)t/ha (Co.det)**
T1 – Rc Sole	Y=-1.33+0.384X+0.00004X2 (0.982)	Z= -0.036+0.007X+0.00004X2 (0.985)	Z= -0.082+0.031Y(0.979)
T2- Pp Sole	Y=-1.35+0.387X+0.00003X2 (0.984)	Z= -0.036+0.007X+0.00004X2 (0.987)	Z= -0.082+0.031Y(0.98)
T3-Gn Sole	Y=-1.39+0.391X-0.00008X2 (0.981)	Z= -0.037+0.007X+0.00003X2 (0.984)	Z= -0.085+0.031Y(0.979)
T4-Pp & Rc strip cropping	Y= -1.47+0.392X-0.0002X2 (0.973)	Z= -0.41+0.007X+0.00003X2 (0.975)	Z= -0.092+0.031Y(0.979)
T5- Pp & Gn strip cropping	Y= -1.53+0.391X-0.0002X2 (0.975)	Z= -0.041+0.007X+0.00003X2 (0.978)	Z= -0.075+0.03Y(0.976)
T6-Rc+Pp (5:2) intercropping	Y= -1.57+0.394X-0.0004X2 (0.974)	Z= -0.045+0.008X+0.000001X2 (0.907)	Z= -0.041+0.024Y(0.921)
T7-Gn+Pp (4:2) intercropping	Y= -1.59+0.388X-0.0004X2 (0.968)	Z= -0.039+0.007X+0.000002X2 (0.900)	Z= -0.046+0.024Y(0.922)
T8-Uncultivated fallow	Y= -1.23+0.387X+0.0003X2 (0.983)	Z= -0.042+0.009X+0.00007X2 (0.985)	Z= -0.127+0.041Y(0.975)
T9-Cultivated fallow	Y= -1.23+0.414X+0.0003X2 (0.972)	Z= -0.054+0.011X+0.00006X2 (0.972)	Z= -0.116+0.041Y(0.986)

Conclusion

Thus it can be concluded that intercropping of groundnut with pigeon pea planted along contour may be practiced to increase crop yield and lowering the soil loss and runoff in the hilly tribal areas of Kandhamal district. The relationship among rainfall, runoff and soil loss was found out which can be used to predict the runoff and soil loss from rainfall for same type of soil condition and slope.

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Conflict of interest

None.

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